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An attempt was made to increase moistness of Jewel variety sweet potatoes by canning the product using a slow heat process allowing time for increased alpha-amylase activity and to assess the influence of this procedure on the classification of the canned product by mouthfeel. Moistness of sweet potato samples canned using 30, 60, and 90 minute holding periods in a hot water bath was compared with that of samples canned with no holding time. Both objective and sensory tests were employed to measure this moistness.

Firmness of sweet potatoes canned by each method was compared using shear-press measurements. Viscometric determinations were taken to show the degree to starch conversion to soluble carbohydrate that occurred as a result of the slow heating. Drained weight determinations were used to indicate the degree of fragmentation occurring in sweet poatoes canned by each method. Canned products were exposed to mechanical abuse expected in transport to observe differences in product breakdown in the four variables. Panelists were asked to rank the samples as to observed breakdown. Dried weights were taken to determine the relationship between apparent moistness and actual water content. Two variations of panel evaluation were carried out to determine if mouthfeel differences in samples could be detected by panel members.

Results show definite differences in starch composition of the four samples. Viscosity determinations show increased starch degredation during the most pronounced slow heating procedure. Shear press and drained weight measurements show no differences in firmness of samples canned by slow and fast heat processes. Sensory ranking on observed product breakdown showed no detrimental breakdown in either group. In ranking and triangle tests panel members were not able to distinguish between sweet potatoes canned by fast and slow heat procedures.

THE EFFECTS OF SLOW HEATING DURING CANNING ON THE MOUTHFEEL CHARACTERISTICS OF SWEET POTATOES

by

Janna Harris Scruggs

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Approved by

Joan F. Cassilly

Thesis Adviser

APPROVAL SHEET

This thesis has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

Thesis Adviser Joan P. Cassilly

Examination Committee Albert E. Purcell

Aden C. Magee

Mildred B. Johnson

July 7, 1975

Date of Acceptance by Committee

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CHAPTER I

INTRODUCTION

Mouthfeel is defined by Matz as the "mingled experience deriving from the sensations of the skin in the mouth after ingestion of a food or beverage" (1). Total mouthfeel is dependent on the density, firmness, viscosity, surface tension and wholeness exhibited by the food.

The many varieties of sweet poatoes (Ipomoea batatas) available to consumers are classified by the Food Buyer's Information Guide into two types, a dry type becoming dry and mealy when cooked and a moist type becoming soft and watery when cooked (2). Mouthfeel can be denoted either moist or dry depending on the sweet potato variety under investigation and on the treatment given any particular variety after harvesting. Moistness refers to the organoleptic perception of moisture and is independent of actual water content.

Sweet potatoes remain high in starch and low in sugar content during their growing season but after harvesting show an increase in concentration of an amylolytic enzyme which creates an environment for starch degradation as the roots are cooked. Alpha-amylase is the enzyme capable of hydrolyzing starch into a mixture of dextrin, and maltose at temperatures between 73 and 78°C.

Freshly dug sweet potatoes are often cured for about 10 days at 30°C and 90 per cent humidity and stored from two to five months in a dry place at temperatures between 16 and 20°C. Curing and storage allow additional time for enzyme concentration to increase and as a result create moistness in cooked sweet potatoes. However, pectin changes upon prolonged storage may produce a canned root which is too soft. Breakdown of sweet potato sections in the can decrease the product's attractiveness. Furthermore, the dry varities may lack sufficient amounts of intrinsic alpha-amylase to bring about significant starch degradation even after a curing and storage period.

A slow heat canning procedure taking the roots slowly through the temperature range optimal for alpha-amylase would allow increased time for enzyme action on the large starch molecules and may lead to increased moistness. An enzyme enhancing step during canning would provide a means of improving mouthfeel in drier varieties and increase their market value. A reduction of the time, personal attention and fuel costs involved in the curing and storage procedure would be economically valuable to sweet potato processors. An improved canned sweet potato with the firm texture necessary for use in its whole form yet the moistness desired by consumers prefering the "yam type" sweet potato may increase the value of the sweet potato as a commercial crop.

Moistness of the enzymatically enhanced product can be assessed by shear press and viscometric determinations which reveal firmness and consistency of the product. Amerine et al. (3) have stated that mouthfeel and rheological behavior are closely related and correlate with viscosity and shear determinations. In addition shear press determinations and mechanical action to simulate transport will indicate if treatment to increase moistness has led to detrimental product breakdown of the sweet potato sample that would jeopardize its economic value.

Sensory evaluation of the sweet potato will indicate if differences in mouthfeel can be detected by panel members. In order to be of importance to the overall quality of sweet potatoes, moistness should be detectable both by panel members and by viscosity determinations of the starch purees.

The purpose of this study was to attempt to increase moistness of canned Jewel variety sweet potatoes by using a slow heat canning process which allows time for increased alpha-amylase activity and to assess moistness by objective and sensory tests.

CHAPTER II

REVIEW OF LITERATURE

Changes occurring in carbohydrate composition of the sweet potato as the roots are stored, cured, preserved and prepared for the table have been investigated extensively in attempts to improve quality and acceptance by the consumer. Carbohydrate is the major component of the sweet potato root being 88 per cent of the dry matter (4).

Muller-Thurgau (1882) confirmed that starch to sugar changes in sweet potato is an enzymatic process (5). In 1890 Stone (6) confirmed the presence of sucrose in the sweet potato. Through research completed in 1911 Hasselbring and Hawkins (7) concluded that during growth the sweet potato root contains mostly starch but after harvest develops significant amounts of cane sugar due to unexplainable internal causes. In a later study these researchers referred to such causes as an enzymatic process (8). Studies in 1912 at the South Carolina Experimental Station showed that variety under investigation, degree of fertilization, and storage time were all significant factors in starch to sugar conversion occurring in harvested sweet potatoes (9). About this same time Miyaka (10) was able to extract specific sugars; glucose, fructose and sucrose from sweet potato root. Gore (11) in 1920 demonstrated that amylolytic enzymes were responsible for carbohydrate transformations and that slow cooking of sweet potatoes through a range of 60°C to the boiling point gave a high conversion of starch into soluble carbohydrate.

Culpepper and Magoon (12) called the enzyme responsible for this starch to sugar conversion diastase and found that its presence varied greatly in different strains of sweet potatoes bringing about a range of moistness and dryness in different varieties. Further the researchers concluded that the sucrose content of a cured sweet potato was three to four times that of an uncured sample and that the flavor of a cured sample was superior. Altered storage time was investigated as a means of producing sweet potatoes with firm enough texture for use in a baked, candied or sauteed form yet with sufficient starch conversion to bring about a sweet flavor. As early as 1926 it was suggested that an enzyme enhancing step in certain varieties might render them acceptable for culinary use in their whole form when freshly dug.

Hopkins and Phillips (13) showed that 2.5 per cent sucrose content of a freshly harvested root changed to 3.3 per cent during a curing period at 10 to 15^{o}C. Barham and Wagoner (14), in an attempt to evaluate sweet potato starch as a possible substitute for tapioca starch, cured sweet potatoes for prolonged periods up to 19 weeks to allow sufficient time for enzyme concentration to increase and produce better pasting characteristics. These investigations showed starch changes as to molecular diameter, density, water holding capacity and permeability when exposed to an extensive curing process.

Sistrunk, et al. (15) found the three principle sugars in sweet potatoes were sucrose, fructose, and glucose. Lambou (6) found sucrose to be the principle sugar in the raw root (66-75 per cent) with significant amounts of glucose (7 - 11 per cent) and fructose (6 - 11 per cent).

Sistrunk (16) found that preheating during canning would increase total sugars in processed sweet potatoes. Heating to the boiling point increases sugar content before inactivating proteinaceous enzymes.

Cooley et al. (17) investigated three, five, and seven month storage periods at 10, 14, and 16°C to determine how storage time and temperature affected percentage of sound potatoes, weight loss and amount of decay. It was found that 14 to 16°C storage produced conditions most favorable for sweet potato life processes. This work revealed the tremendous sensitivity of sweet potatoes to treatment after harvest. Length and condition of storage, cure, and heat treatment during processing were significant factors in sweet potato quality. All sweet potato varieties under investigation were judged to need moderate storage at relatively warm temperatures in order to be acceptable for many culinary uses.

Jenkins and Geiger (18) baked samples of both freshly harvested and cured sweet potatoes to test for carbohydrates. It was found that half the starch in a freshly dug root was available for conversion to sugar while considerably more than half the starch of a cured root was available for conversion to sugar in a seven week period. This cured sweet potato sample when baked had the finest texture and moistest taste of all samples under investigation, as judged organoleptically by a sensory panel. This suggests that both curing and baking increased enzymatic processes responsible for carbohydrate transformations.

Sistrunk (16) judged conditions of pH to be as effective on color and firmness of canned sweet potatoes as was curing and storage.

When the normal pH of 6 of canned samples was increased more starch to sugar conversion was observed. Both color and moistness of sweet potato samples was affected by pH.

The large proportion of starch to soluble sugars in certain dry varieties and in all freshly dug sweet potatoes gives these roots dry mouthfeel characteristics, often a lack of sweetness, and a mealy texture. However drier potatoes are in demand for some purposes (19). Kelly (20) found dry varieties to be acceptable in production of sweet potato chips. Chips made from dry varieties grown in Pennsylvania were rated crunchy by a consumer-type taste panel while chips from moist varieties were rated tough and chewy. Sweet potatoes cut into julienne strips and deep fat fried showed increased acceptance when dry varieties were used.

Early attempts to utilize dry varieties and uncured roots in production of sweet potato flakes were unsuccessful because the flakes would not stick to the drying drum properly, they were porous, and had low bulk density. Hoover (21) attempted addition of an amylolytic enzyme, Rhozyme S, to a cooked sweet potato puree to hydrolyze a portion of the starch and allow freshly harvested roots and large, odd-shaped roots to be used for flake production. It was found that flavor, texture and appearance of the sweet potato flakes improved proportionally with the amount of soluble solids developed in the roots as a result of enzyme activity. Realizing the advantage of activating the naturally occurring enzyme for starch hydrolysis rather than the costly addition of enzyme, in a later study Hoover (22) attempted to activate the sweet potato amylase by holding the pre-heated puree for a 10 to 15 minute conversion period. Organoleptic evaluations and objective tests revealed increased sweetness and improved bulk density in sweet potato flakes exposed to the holding time. Ikemiya et al. (23) suggested that firmness of sweet potatoes canned within a few days of harvesting may be attributed to their low alpha-amylase.

Walter and Purcell (24) suggest that alpha-amylase may affect mouthfeel characteristics of sweet potato roots used for canning in a manner directly proportional to time available for enzyme action on large starch molecules. Nelson (19) demonstrated that canning using a slow heat treatment created by holding cured roots in a 80^{o}C water bath before retorting produced a more moist product as rated by a sensory panel and resulted in moistness determinations which correlated significantly with shear press testing.

Attempts have been made to assess moistness and dryness of food samples by shear press and viscometric determinations. Textural changes in canned peaches have been shown to be a result of pectin changes and a significant factor in their acceptance by consumers. Readings obtained from a Kramer shear press on firmness of canned peaches correlated with panel evaluations of firmness. Non-Newtonian materials can be successfully evaluated for viscosity by a rotating cylinder-type viscometer. Mouthfeel is closely related to rheological properties and to sheer behavior (3, 25, 26).

Sistrunk (16) used a shear press to measure changes to firmness in canned sweet potatoes as influenced by pH, storage, and variety. Culpepper and Magoon (12) used plasticity tests to compare the firmness of fresh sweet potatoes with cured roots by recording the resistance of samples to penetration by a plunger. Barham and Wagoner (14) used a rotating cylinder viscometer to determine the viscosity of sweet potato pastes taken from 1 to 19 week storage periods.

Sensory evaluation is the most important factor in food analysis since consumer acceptance is the ultimate test of food quality. Panel evaluations are influenced by human judgment, sensitivity, past experiences, and prejudices. Peryam and Swartz (27) define ideal panel evaluation as a situation precise enough to allow human responses to be treated as statistical units while at the same time controlled enough to reduce the impact of human factors. Foster (28) discussed motivation as the most important criteria for selection of panel members. When high school students selected for a taste panel were given a Personality Research Form in order to ascertain which personality traits correlated with superior food judging ability, Henderson and Vaisey (29) found judges scoring high in the need to achieve category were the best discriminators of flavor differences. Aggression, autonomy, harm avoidance, and impulsiveness were also closely related to food discrimination ability.

Screening tests, such as those used by Harrison and Elder (30), consisted of a training period of prospective panel members on detecting a particular aspect of a food product followed by a series of blind tests detecting samples exhibiting the described characteristic. Foster (28), however, did not find pre-testing for sensitivity to be valuable in predicting future panel performance but listed sex, age, health, motivation, sensitivity, intelligence, economic status, and occupation as significant factors in panel selection.

Matz (1) suggested ways of "objectifying" panel members by selecting people experienced in organoleptic testing, screening and training these members and using replicated testing on these few rather than striving for increasing the number of judges. A few well-selected and trained judges having similar characteristics of aptitude, sensitivity and motivational level are thought to be superior to a large untrained panel. Griswold (31) suggests 4 to 12 members for a trained panel with enough replications to produce sufficient statistical units for analysis. This small expert panel functions as a piece of testing equipment thus making sensory evaluations more objective. Small panels reduce cost of research and make statistical analysis more precise.

Krum (32) gave 20 to 50 as the ideal age range for panel members since sensory ability diminishes after 50 and members younger than 20 may lack experience. Sex was not seen as significant by Krum since taste and odor discriminations are not sex-linked or sex-influenced. Some authors state that smoking has not been shown to be detrimental to judging ability (1, 31).

Environmental factors in taste panel evaluations have been investigated. Foster (28) found temperature, humidity, source of ventilation,and illumination of the test room to be significant factors. Krum (32) found it important that all tests in a series be carried out in the same room and in a quiet pleasant atmosphere. Experimental design and method of data analysis are vital in assessing organoleptic properties of food scientifically and objectively.

CHAPTER III

EXPERIMENTAL PROCEDURE

Canning

Sweet potatoes used in this study were grown at the North Carolina State University Agriculture Experimental Station at Clayton, North Carolina. Jewel variety sweet potatoes harvested in early October were selected for testing and were cured at 30°C and 80 to 90 per cent relative humidity for 11 days. After the curing stage they were stored at 13°C and 30 per cent relative humidity until canned on December 17, 1974.

Before canning the sweet potatoes were washed in a 10 per cent NaOH solution at 99°C for eight minutes and sprayed with cold water to remove the peels. Potatoes were hand-trimmed and cut into approximately two inch sections. Number 303 enamel-lined cans were filled with the sweet potato sections and a 25 per cent sucrose solution.

A control group of 24 cans labeled 0 was heated, vacuum exhausted, mechanically sealed, and retorted immediately at 121°C for 60 minutes. Three additional groups of 24 cans each were treated in an identical manner except for an additional holding period in a hot water bath at 80°C for 30, 60, and 90 minutes, respectively, before the retorting process. Retorting times for the 60 and 90 minute groups were adjusted to 55 and 50 minutes respectively to compensate for the cooking and heat conduction occurring during the holding period. After retorting all 96 cans were placed in cold water for cooling and stored at room temperature.

Simulated Transport

After a two week storage period to allow for hardening four unopened cans from each treatment group were selected at random and placed on a rotary shaker to simulate movement expected in transportation of canned goods. The shaker ran for 15 minutes at 210 rotations per minute. After shaking, cans were dropped to the floor five times from a table surface 87 cm. high to simulate possible abuse in the loading, unloading, and stocking which occurs between processing and delivery to the consumer.

A sample can from each group treated in this way was opened and its contents poured into a 250 ml. beaker. Three-digit code numbers were assigned to the four beakers. Eight staff members in the Food Science Department at North Carolina State University were asked to rate the beakers of sweet potatoes as to total breakdown resulting from the mechanical action. The judges were presented the four beakers on a tray and asked to arrange them in order of breakdown.

Shear-Press Measurements

Fifty gram samples of the canned sweet potatoes from each treatment group were evaluated for firmness using the standard shear-compression cell, Model CS-1 (Food Technology Corporation) in conjunction with the Instrom Universal Testing Instrument Model 1130 in the Department of Food Science at North Carolina State University. The shear-compression cell is made up of a series of parallel blades that can be forced into a food sample shearing it into a collection compartment. Peak force readings were recorded for the control and for each of the three treatment variables. Crosshead and chart speeds of 200 mm/minute and a 50 gram force transducer were selected for this series of measurements. Four replications were taken on each group.

Viscosity Determinations

Sixty gram portions of the composite sweet potato residue from each group left in the cell collection compartment after shear-press measurements were made into purees. Each 60 gram residue was mixed with 15 ml. water giving a four part sweet potato to one part water ratio and the purees were allowed to stand for three hours before testing. Viscosity determinations were made with a Haake Rotovisco Model RV-1 Viscometer at the Food Science Department at North Carolina State University. Purees were placed one at a time into the SV-IIP chamber of the viscometer and readings were taken at a speed factor of nine representing 64.8 revolutions per minute. Control panel readings were taken to show the force required to stir the purees.

Fragmentation, Drained Weight and Dry Weight

Fragmentation was determined by emptying the contents of a can from the control group into a # 5 sieve and then into a # 80 sieve and calculating the ratio of the contents in the two sieves. Standardized mesh sieves from the American Society of Testing Materials were used for fragmentation and drained weight determinations. A number 5 sieve has openings of .175 inch and a number 80 sieve has openings of .0070 inch. The sum of the contents of the sieves was calculated to determine drained weight. This was repeated for the three treatment variables.

Dried weights were obtained by weighing samples from each group and drying in an oven at 41°C for 20 to 24 hours. Samples were then reweighed and dried weights recorded.

Panel Evaluations

To assess differences in mouthfeel of the four variables, both ranking tests and triangle tests were administered to selected panel members. All sensory evaluation was carried out in a food preparation laboratory in the School of Home Economics at the University of North Carolina at Greensboro.

In a series of ranking tests five women students were selected for their similarities in aptitude, age, interests, level of motivation and experience with food testing. All five panelists were graduate students in foods and nutrition, all were over twenty and all had participated in previous taste panel work.

An informal preliminary training session was set up to discuss moistness and dryness of mouthfeel. All members received identical instruction during the training session (See Appendix A). An experimental sweet potato variety #213X228-1 developed at the Horticultural Department at North Carolina State University by Dr. Daniel Pope was canned by the researcher to demonstrate to the panel members an extremely dry root.

Ranking evaluations were repeated four times with two sessions being conducted in mid-morning and two in mid-afternoon. Samples from each treatment group were cut identically into one inch sections and presented similarly as to grain orientation. Care was taken to use as many sweet potato sections as possible to prepare the samples presented at each sitting. Sections from several cans from a particular group were mixed to insure randomness of samples. Panel members were scheduled to arrive for panel evaluations in fifteen minute intervals so that each panel member worked alone in the laboratory. For testing the panelists were provided with a napkin, fork, glass of tap water, pencil, score sheet and samples to be ranked.

A one-inch cube from each treatment group was placed on a white paper plate and labeled with a three-digit code. A one-inch cube of the dry standard was presented on a separate white paper plate. A table of 20 code numbers was prepared for use in labeling the samples so that codes for a particular treatment sample could be varied with each replication of the test. Position on the plate of the 0, 30, 60 , and 90 minute samples was changed with each replication of the ranking tests. Panel members were asked to rank the four coded samples on a scale from 1 to 4 as to how closely they resembled the Dry Standard. The score sheet used for the ranking evaluations is given in Appendix B.

Triangle Tests

Twelve students in the Foods and Nutrition Department at the University of North Carolina at Greensboro were selected to participate in triangle tests on the sweet potato samples. Each student repeated this three times giving 36 evaluations.

Panel members were presented three samples, two alike and one different and asked to pick out the odd sample and comment on how it was different. Tests were conducted mid-morning and mid-afternoon in the food preparation laboratory. A test situation identical to the one described above was set up for triangle testing. However, no preliminary training was attempted. The score sheet used for the triangle tests is shown in Appendix B.

CHAPTER IV

RESULTS AND DISCUSSION

Sweet potatoes of the Jewel variety were selected for use in this study because in previous research conducted by Nelson using six sweet potato varieties, Jewel was rated as a moderately moist / moderately dry variety. Of further importance, 90 per cent of the sweet potatoes grown in North Carolina are of the Jewel variety. The dry strain canned for use as the dry standard in ranking tests exhibited notable dry mouthfeel characteristics.

Sweet potatoes from all four treatment groups appeared whole after exposure to the mechanical shaking action according to separate rankings by Food Science staff personnel. Rankings were averaged for each sample and were found to be:

Sample 0	2.0
Sample 30	4.0
Sample 60	1.8
Sample 90	2.0

Sample 90 was ranked as most whole as often as was Sample 0 indicating no significant breakdown occurring as a result of slow heating. All four treatment variables maintained wholeness, indicating that no damage to pectin had occurred even during the 90 minute holding period. Pectinase enzymes that hydrolyze pectin work at a lower temperature than alpha-amylase and are inactivated before the starch gelatinizes. The slow heating during canning would not be expected to cause pectin fragmentation or decreased firmness. Complete ranking data can be found in Appendix C.

Results obtained from the shear-press (Table 1) show no differences in the firmness of sweet potatoes canned at different holding times. Differences in average shear press force values on Sample 0 and Samples 30, 60 and 90 were nearly negligible. Force values between any two variables differed no more than .1 kilogram. In light of these similarities of shear press values denoting firmness, the lack of observable differences in wholeness resulting from mechanical action is not surprising.

Since the integrity and wholeness of canned sweet potato sections are important to their culinary usefulness, breakdown is undesirable. Therefore, firmness of samples canned by the slow heat processes suggests a successful treatment. Wholeness can not be sacrificed for increased moistness. Pectin substances responsible for firmness should still be intact in all samples and the 30, 60, and 90 minute samples would be expected to exhibit increased moistness but no decrease in firmness as measured by the shear-press.

Puree made from the control sample was most viscous as rated by the Haake Rotovisco Viscometer. Samples 30 and 60 showed decreasing viscosity in that order and puree made from Sample 90 exhibited the lowest viscosity rating. Viscosity of a starch paste depends on the size of the starch molecule. Carbohydrate transformations resulting from the alpha-amylase activity would bring about a decrease in molecular weight of the starch molecule allowing more water to be bound in the interior. The viscosity of sweet potato puree is determined by the spacial relationship of moisture to starch rather than actual moisture content. The lowered viscosity of Sample 90 suggests

Table 1. Shear press force values (kg.).

	First Trial	Second Trial	Averages
0	4.35	5.65	5.0
30	4.70	5.40	5.0
60	5.60	4.70	5.3
90	5.00	4.80	4.9

Table 2. Viscosity determinations at 9 rpm motor speed.

	First Trial	Second Trial	Averages
0	40	40	40
30	26	27	27
60	23	25	24
90	5	6	6

increased starch to sugar conversion has occurred during the holding period in the hot water bath. Table 2 shows viscosity determinations.

The drained weights of the contents of a can from each group were similar suggesting equal degrees of breakdown in sweet poatoes canned by fast or by slow heat procedures. The ratios of retention in the #80 sieve to retention in the #5 sieve were closely related. Similarities of drained weights were consistent with failure of panel members to detect visual signs of product breakdown.

After oven drying a sample from the control group weighed no more than samples from the treatment variables. Water content was similar in all products and appeared to be independent of viscosity. Sieve retention, drained and dried weights are shown in Table 3. Water content would be expected to be similar in equal weight samples canned by slow and by fast heat processes. The way in which water is bound in the carbohydrate matter rather than the actual moisture content determines moistness and dryness of a sweet potato. Water is less tightly bound in the smaller starch fragments and its presence is more easily detected creating apparent moistness in mouthfeel.

Table 4. Drained Weights and Dried Weights

	Weight (gm.)	Dried Weight (gm.)
Sample 0		
Contents of #5 sieve	292.83	
Contents of #80 sieve	36.83	
Ratio of contents	7.95	43.00
Total drained weight	329.66	
Sample 30		
Contents of #5 sieve	223.04	
Contents of #80 sieve	37.60	49.73
Ratio of contents	5.932	
Total drained weight	260.64	
Sample 60		
Contents of #5 sieve	271.23	
Contents of #80 sieve	26.35	45.23
Ratio of contents	10.29	
Total drained weight	297.58	
Sample 90		
Contents of #5 sieve	309.85	
Contents of #80 sieve	25.23	42.87
Ratio of contents	12.81	
Total drained weight	335.08	

Separate rankings by the five trained graduate students show no correlations. Sample 0 was judged most similar to the Dry Standard as often as was Sample 90. Comments from panel members indicate that detecting a difference was difficult and further suggests similarity of the samples. Kramer (33) has developed a method for determining significance of difference from rank sums. In order for significance at the .05 level to occur, rank sums of any treatment in an analysis using five panelists and four replications must fall between 23 and 62. Appendix C shows rank sums of each category to lie outside this range.

Twelve Foods and Nutrition majors were not able to correctly select the odd sample in repeated triangle tests. From 36 trials only 11 correct selections were made, and no panel member indicated texture or mouthfeel as the factor that was different about the odd sample selected. Completely random guessing in triangle tests would provide a 33 1/3 per cent probability of a correct answer. Krum gives data showing the number of correct answers necessary to establish significance differences at the .05 probability level would be 18 out of 36 triangle tests (32).

The commercial crop value of the sweet potato in the United States is significant. The North Carolina crop was valued at 10 million dollars per annum in 1967 (19) and suggests potential for increased value. Since the sweet potato is of tropical origin, it is grown during a relatively short period of the year and must be stored or preserved in some way if it is to remain on the market the entire year. Numerous authors have investigated the storage and curing conditions that best enhance sweet potato quality (7, 12, 14, 17), and dehydration into sweet potato flakes has been successful (21, 22). Improving canning procedures to produce a root desired by the consumer might further increase its commercial value. Variations of the canning procedure attempted in this study had an influence on starch to sugar conversion as indicated by viscosity readings but did not produce differences detectable by a sensory panel. Objective measurement by the viscometer is more precise than panel evaluation and would be able to indicate changes in carbohydrate composition undetectable by sensory means.

The sweet potatoes used in this study had been exposed to a curing and storage procedure allowing time for a pronounced increase in alpha-amylase before canning. Sufficient enzyme was present in the roots to create moistness in all four treatment groups and obscure detectable moistness differences. Viscosity readings did indicate increased starch degradation in the samples canned by a slow heating process with the longest holding period giving the most starch breakdown.

CHAPTER V

SUMMARY AND CONCLUSIONS

The Jewel variety sweet poatoes canned for this study were cured and stored to allow time for the concentration of intrinsic alpha-amylase to increase. The heat during canning by both the fast and slow heat processes created an environment for sufficient enzyme activity to create moist mouthfeel in all four treatment groups. A lower viscosity determination of Sample 90 indicated greater starch degradation with the most pronounced slow heating. Organoleptic testing did not produce evidence of moistness differences. All four samples presented to panel members were sufficiently moist to obscure differences created by fast or slow heating.

The following conclusions can be drawn from this research:

1. Purees made from sweet potatoes canned by a slow heat process were less viscous than purees made from sweet potatoes canned by a fast heat process.

2. Firmness of samples canned by slow heat did not differ appreciably when shear press force values were taken.

3. Wholeness was maintained in equal degree by all canned samples exposed to mechanical abuse.

4. Drained weights suggest no greater breakdown in sweet potatoes canned by slow heat than by fast heat.

5. Water content of all canned samples was similar.

6. Trained food judges experienced in organoleptic testing were not able to detect and rate differences in mouthfeel by ranking or by triangle tests.

The canning treatment in the completed research was successful in altering carbohydrate composition of sweet potato roots but did not appear to create detectable moistness of sweet potato samples. Further research would be valuable to determine if an enzyme activation time longer than 90 minutes in the 80^{o}C water bath would create moist mouthfeel characteristics important to the overall evaluation of product quality. A similar canning treatment on early season roots may produce moistness detectable by objective measures and correlated with sensory evaluation.

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Appendix A

INSTRUCTIONS FOR TASTE PANEL MEMBERS

INSTRUCTIONS FOR TASTE PANEL MEMBERS

Mouthfeel is defined as the mingled experience derived from the sensations to the skin in the mouth after the ingestion of a food. It relates to density, viscosity and surface tension. For the purposes of this test you are asked to distinguish dry mouthfeel from moist mouthfeel. Dry mouthfeel has been defined as pasty, mealy and tending to cling to the mouth surface. Moist mouthfeel is slick to the mouth lining and easier to swallow. The samples you are asked to taste should be ranked by dryness as they compare to the dry standard. Decide how the four coded samples compare in mouthfeel to the dry standard and rank them accordingly on the score sheet. You should break the sample apart with the fork and place a portion in your mouth. Slide the product across the roof of the mouth with your tongue. Do not be confused by trying to detect moisture content in the sample. Remember that dry is pasty and moist is slick. You may drink water between samples and the samples can be swallowed since taste is not a factor in how the samples rank. Please rank as nearly as you can even if you detect little differences in the samples. Feel free to indicate possible difficulty in ranking in the space provided for comments. Please do not discuss your participation in the panel evaluations with anyone else. Thank you.

Appendix B

SCORE SHEETS

SCORE SHEET USED IN RANKING EVALUATIONS

Name ______________________________ Date ______________

Directions: Please rank these samples as they compare in mouthfeel to the dry standard. Place the three digit sample code opposite the rank.

	Rank	Sample Code
Most similar to dry standard	1	________
	2	________
	3	________
Most unlike dry standard	4	________

Comments: ____

____

SCORE SHEET USED IN TRIANGLE PANEL TESTS

Name ____ Date ________

Directions: Two samples are alike and one is different.

(1) Which sample is different? a b c (circle one)

(2) How is it different? ______________________________

____

(3) Which do you prefer?
the two alike samples ________
the different sample ________

Appendix C

RANKING DATA

Data obtained from panel members asked to rank samples in order of observed breakdown[a]

1st member

1 - 815 (90)

2 - 453 (0)

3 - 397 (60)

4 - 628 (30)

2nd member

1 - 815 (90)

2 - 453 (0)

3 - 397 (60)

4 - 628 (30)

3rd member

1 - 815 (90)

2 - 397 (60)

3 - 453 (0)

4 - 628 (30)

4th member

1 - 397 (60)

2 - 453 (0)

3 - 815 (90)

4 - 628 (30)

5th member

1 - 397 (60)

2 - 453 (0)

3 - 815 (90)

4 - 628 (30)

6th member

1 - 397 (60)

2 - 453 (0)

3 - 815 (90)

4 - 628 (30)

7th member

1 - 397 (60)

2 - 453 (0)

3 - 815 (90)

4 - 628 (30)

8th member

1 - 815 (90)

2 - 397 (60)

3 - 453 (0)

4 - 628 (30)

[a]position 1 designated as most whole

Ranking data from five selected panelists

FIRST MEMBER

	Trial 1	Trial 2	Trial 3	Trial 4
1	60	90	30	30
2	90	0	90	90
3	30	60	0	0
4	0	30	60	60

SECOND MEMBER

	Trial 1	Trial 2	Trial 3	Trial 4
1	60	60	90	90
2	0	0.	0	30
3	30	90	30	0
4	90	30	60	60

THIRD MEMBER

	Trial 1	Trial 2	Trial 3	Trial 4
1	60	0	90	90
2	0	30	30	30
3	90	60	0	0
4	30	90	60	60

FOURTH MEMBER

	Trial 1	Trial 2	Trial 3	Trial 4
1	90	30	60	30
2	0	0	90	90
3	60	90	30	60
4	30	60	0	0

FIFTH MEMBER

	Trial 1	Trial 2	Trial 3	Trial 4
1	60	60	90	30
2	0	0	30	90
3	30	30	0	60
4	90	90	60	0

Data obtained from triangle tests

Panelist	Trial 1	Trial 2	Trial 3
1	Incorrect	Correct	Correct
2	Incorrect	Correct	Correct
3	Incorrect	Incorrect	Incorrect
4	Incorrect	Incorrect	Incorrect
5	Correct	Correct	Incorrect
6	Incorrect	Incorrect	Correct
7	Correct	Correct	Incorrect
8	Correct	Incorrect	Incorrect
9	Incorrect	Incorrect	Incorrect
10	Incorrect	Incorrect	Incorrect
11	Incorrect	Incorrect	Correct
12	Incorrect	Incorrect	Incorrect
Totals: Correct	3	4	4
Incorrect	9	8	8

36 Evaluations / 11 Correct - 25 Incorrect